NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

High Penetration Photovoltaics Workshop

May 20, 2010
Denver, Colorado

Systems Interconnection Standards and Codes: IEEE 1547 and P2030; Tom Basso, NREL

Content

- Background

  the grid;

  DER interconnection;

  standards and applying standards.

- IEEE 1547 and P2030 Standards
- Closing Remarks

DER Interconnection

Distributed Energy Resources


Fuel Cell


PV


Microturbine


Wind


Energy Storage


PHEV - V2G


Generator

Interconnection Technologies


Inverter


Switchgear, Relays, & Controls

Functions

- Power Conversion
- Power Conditioning
- Power Quality
- Protection
- DER and Load Control
- Ancillary Services
- Communications
- Metering

Electric Power Systems

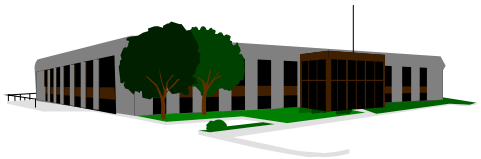

Utility System

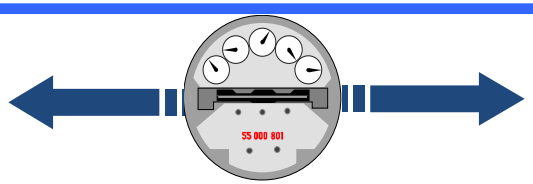

Microgrids

Loads

Local Loads
Load Management

Standards & Conformity Assessment





- Safeguards against hazards
- Fosters quality design and manufacture
- Increases competitiveness in industry
- Creates and expands markets
- Facilitates Trade and Commerce
- Assurance is provided when products meet quality standards, then users need not be concerned with redundant testing or evaluation of the product

- Accelerates engineering advances & implementation, interoperability, and installation
- Assists increased quality and reliability achievement
- Simplifies compliance to needs, permitting, & rules
- Promotes advanced communications; software platforms interchangeability
- Enables enhanced DE systems and grid intelligence
- Lower cost and quicker deployment for projects.

IEEE 1547 Interconnection Standards Use:
Federal, Regional, State and Local Authorities/Jurisdictions .

IEEE 1547
Interconnection System and Test Requirements

- Voltage Regulation
- Grounding
- Disconnects
- Monitoring
- Islanding
- etc.

IEEE 1547.1
Interconnection System Testing

- O/U Voltage and Frequency
- Synchronization
- EMI
- Surge Withstand
- DC injection
- Harmonics
- Islanding
- Reconnection

UL 1741*
Interconnection Equipment

- 1547.1 Tests
- Construction
- Protection against risks of injury to persons
- Rating, Marking
- Specific DR Tests for various technologies

NEC

Article 690 PV Systems;

Article 705: interconnection systems (shall be suitable per intended use per UL1741)

PJM Interconnection, Inc.
Small Generator Interconnection Standards
FERC approved
(0-to<10MW and 10-to-20 MW; incorporate 1547 and 1547.1)

* UL 1741 supplements and is to be used in conjunction with 1547 and 1547.1

- Energy Policy Act (2005) Cites and Requires Consideration of IEEE 1547 Standards and Best Practices for Interconnection.
- Energy Independence and Security Act (2007) Established NIST as Lead to Coordinate Framework and Roadmap for Smart Grid Interoperability Standards and Protocols.

Federal 2009 ARRA:
Smart Grid projects & DER high penetration.

IEEE 1547 Interconnection Standards

1547- 2008 Standard for Interconnecting Distributed Resources with Electric Power Systems

1547.1 - 2005 Conformance Test Procedures for Equipment Interconnecting DR with EPS

1547.2 - 2008 Application Guide for IEEE 1547 Standard for Interconnection of DR with EPS

1547.3 - 2007 Guide for Monitoring, Information Exchange and Control of DR

P1547.4 Guide for Design, Operation, & Integration of Distributed Resource Island Systems with EPS

P1547.5 Guidelines for Interconnection of EPS >10 MVA to the Power Transmission Grid

P1547.6 Recommended Practice for Interconnecting DR With EPS Distribution Secondary Networks

P1547.7 Draft Guide to Conducting Distribution Impact Studies for DR Interconnection

Microgrids

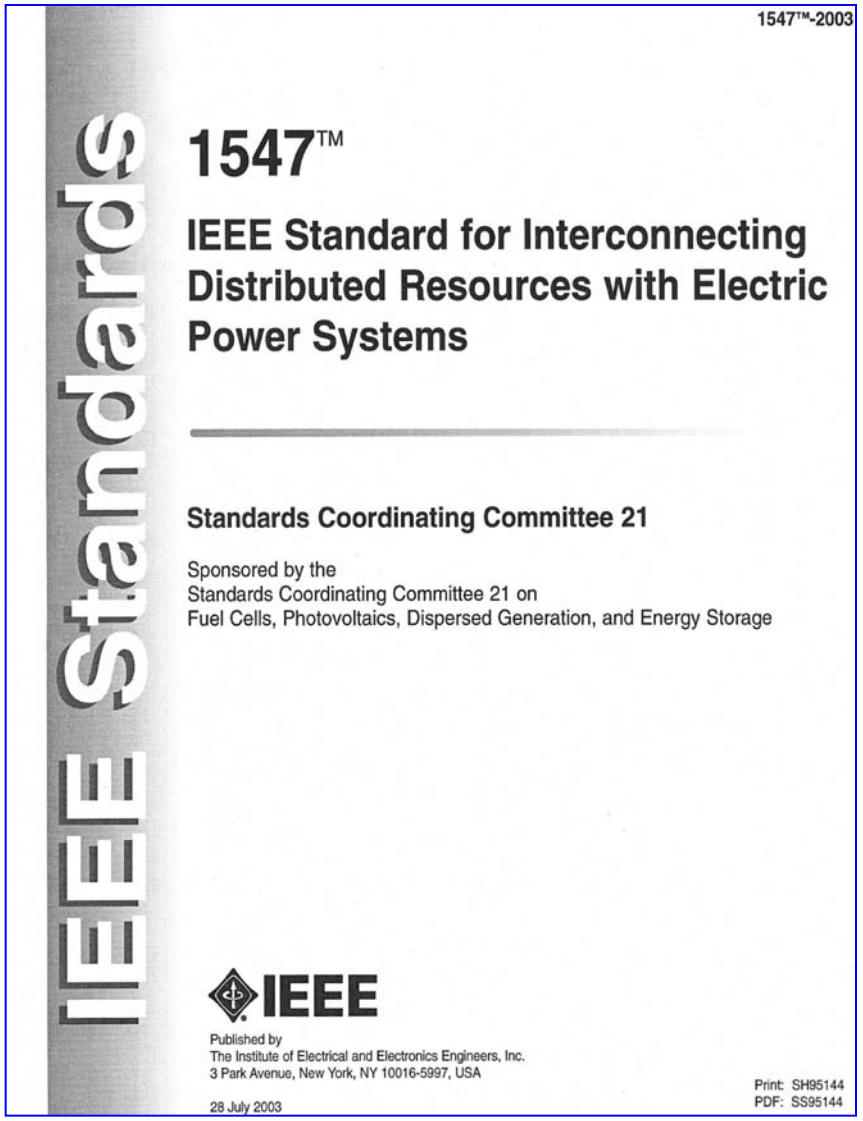
Current 1547 Projects

P1547.8 (new)

Extend use of 1547, e.g. grid support, energy storage, ride-thru, etc.

http://grouper.ieee.org/groups/scc21/index.html

ANSI/IEEE Standard 1547



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4.0 Interconnection Technical Specifications and Requirements:

. General Requirements
. Response to Area EPS Abnormal Conditions
. Power Quality
. Islanding

5.0 Test Specifications and Requirements:

. Design Test
. Production Tests
. Interconnection Installation Evaluation
. Commissioning Tests
. Periodic Interconnection Tests

IEEE 1547 IS:

- **A Technical Standard - Functional Requirements**
  For: the interconnection itself and
- **the interconnection test**
- **Technology neutral, e.g., does not specify particular equipment nor type**
- **A single (whole) document** of mandatory, uniform, universal, requirements.
- **Should be sufficient** for most installations.
- **Requirements apply at point of common coupling** (unless otherwise stated).

IEEE 1547 Is NOT:

- **a design handbook**
- **an application guide**
- **an interconnection agreement**
- **prescriptive, e.g., does not address DR self-protection, nor planning, designing, operating, or maintaining the Area EPS.**

IEEE Std 1547.1 (2005)

… ***Standard for Conformance Test Procedures*** …specifies the type, production, and commissioning tests that shall be performed to demonstrate that interconnection functions and equipment of a distributed resource (DR) conform to IEEE Std 1547.

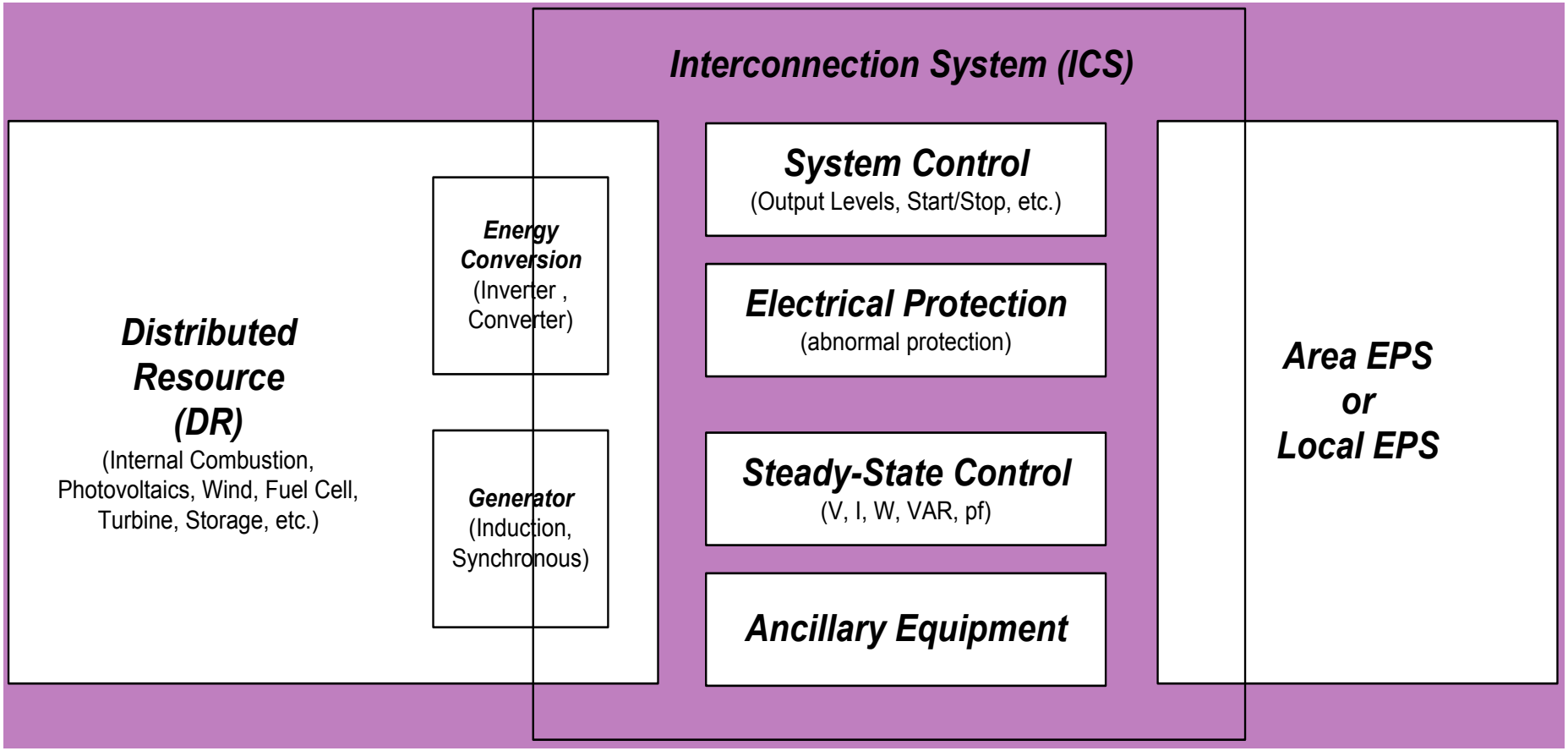
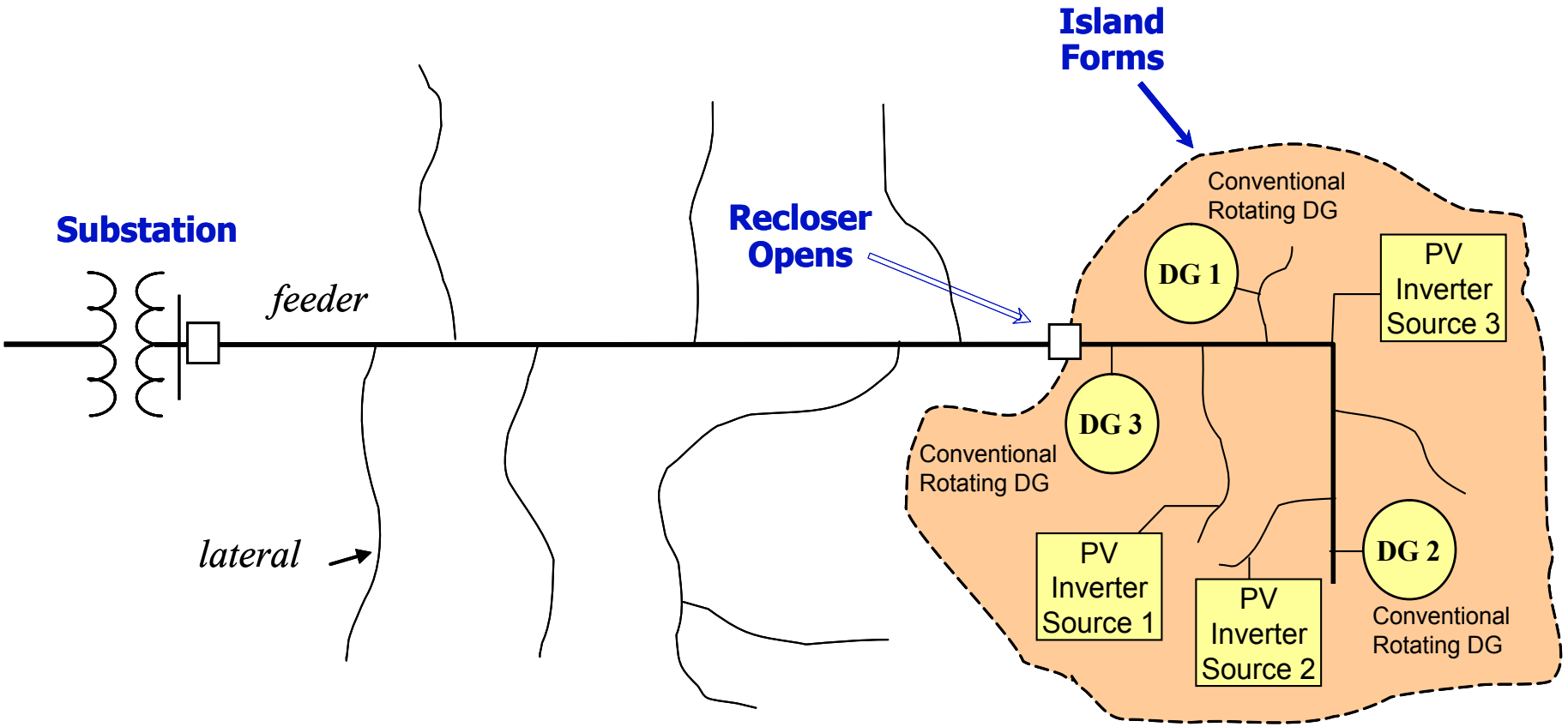


Figure 1. Boundaries between the interconnection system, the EPS and the DR.

P1547.4 (Planned DER Islands) IEEE ballot: Apr-May 2010

E.g., DER (generation and energy storage) technologies are integrated with all others including the grid technologies to form **Micro-grids (planned islands**; includes – load management, voltage & VAR control, active participation, etc.)



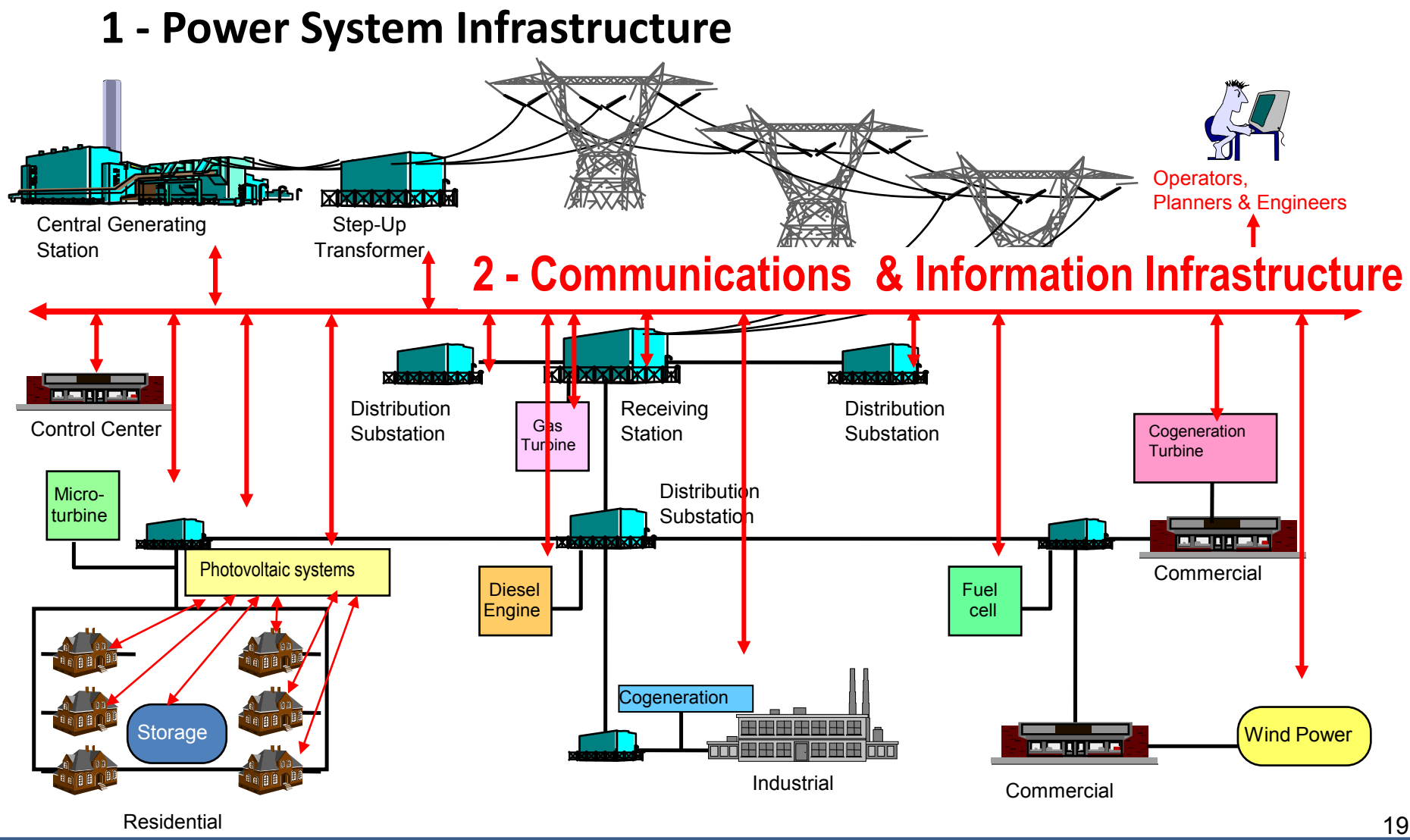
P1547.7 Guide to Conducting Impact Studies

- Describes criteria, scope, and extent for engineering studies of the impact of DR on distribution system.
- Methodology for performing engineering studies.
- Study scope and extent described as functions of identifiable characteristics of:
  - the distributed resource,
  - the area electric power system, and
  - the interconnection.
- Criteria described for determining the necessity of impact mitigation.
- Guide allows a described methodology for:
  - When impact studies are appropriate,
  - What data is required,
  - How studies are performed, and
  - How the study results are evaluated.

P1547.8 Recommend Practice to Extend Use of 1547

- Need for P1547.8 is to address industry driven recommendations and NIST smart grid standards framework recommendations (e.g., NIST priority action plans).
- Example considerations include: low voltage ride thru; volt-ampere reactive support; grid support; two-way communications and control; advanced/interactive grid-DR operations; high-penetration/multiple interconnections; interactive inverters; energy storage; electric vehicles; etc.

The Smart Grid - *the Integration of:* Power, & *Communications and Information Technologies*



IEEE Std P2030 – Smart Grid Interoperability

Draft Guide for Smart Grid Interoperability of Energy Technology & Information Technology Operation with the Electric Power System (EPS) &End-Use Applications & Loads

- Provides guidelines in understanding and defining smart grid interoperability of the EPS with end-use applications and loads
- Focus on integration of energy technology and information and communications technology
- Achieve seamless operation for electric generation, delivery, and end-use benefits to permit two way power flow with communication and control

- Address interconnection and intra-facing frameworks and strategies with design definitions
- Expand knowledge in grid architectural designs and operation to promote a more reliable and flexible electric power system.

Closing Remarks

- IEEE 1547 and IEEE P2030 Standards development facilitate high penetration of distributed energy resources .
- IEEE P1547.4 (micro-grids/planned islands) discusses advanced DER and distribution system operations.
- IEEE P1547.7 is a guide to conducting DER impacts study
- IEEE P1547.8 establishes recommended practices to extend 1547 use (such as voltage regulation, ride-through, grid support, etc.)

Next P2030 and P1547 series meetings

- P2030 Meeting May 25 – 28
- P1547.7 Meeting August 10 – 11
- P1547.8 Meeting August 12 – 13